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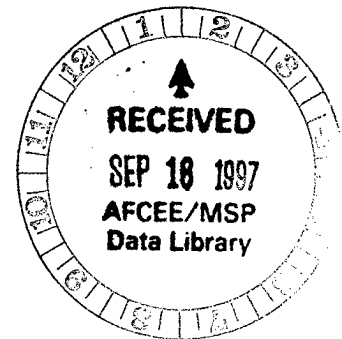
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PARSONS ENGINEERING SCIENCE, INC.

1700 Broadway, Suite 900 • Denver, Colorado 80290 • (303) 831-8100 • Fax: (303) 831-8208

September 16, 1997



Major Ed Marchand
AFCEE/ERT
3207 North Road, Bldg. 532
Brooks AFB, Texas 78235-5363

Subject: Extended Bioventing Testing Results for Closed Waste POL Pit, SWMU 14,
Fort Rucker, AL (Contract No. F41624-92-8036, Order 17)

Dear Major Marchand:

This letter presents the results of the bioventing system monitoring performed by Parsons Engineering Science, Inc. (Parsons ES) in July 1997 at the Closed Waste Petroleum, Oils, and Lubricants (POL) Pit, Solid Waste Management Unit (SWMU) 14, at Fort Rucker, Alabama. Soil gas samples were collected and *in situ* respiration testing was performed by Parsons ES between 13 and 21 July 1997 to assess the extent of remediation completed during approximately 1 year of air injection bioventing. Also, additional soil gas monitoring point (MP) screens were installed and dissolved oxygen (DO) concentrations in perched groundwater were measured during the July 1997 field effort. The purpose of this letter is to summarize site and bioventing activities to date, present the results of the 1-year system monitoring event and compare them with the results of the initial pilot testing event, and to recommend future remediation activities for the site based on these findings.

SITE REMEDIATION HISTORY

SWMU 14 is located in the western portion of Fort Rucker. The site is located on a ridge, and the land slopes downward to the west-southwest (Figure 1). The nearest surface water is a tributary stream located approximately 1,000 feet west (downgradient) of the site. Groundwater beneath the site occurs at a depth of approximately 44 feet below ground surface (bgs); however, a localized, perched, saturated zone occurs between 9 and 15 feet bgs in the area of the closed waste POL pit. During the period from 1978 to 1980, the waste POL pit was used to dispose of contaminated helicopter fuel (JP-4), tanker truck washout fluids, and possibly motor oil. The unlined pit was about 80 feet in diameter and 7 feet deep. The closed waste POL pit is now covered with an additional 7 to 8 feet of clay and soil and partially vegetated with pine trees.

In 1980, soil samples taken from the pit showed traces of trichloroethene. Fort Rucker subsequently notified the United States Environmental Protection Agency (USEPA) and the State of Alabama of the existence of the pit and the analytical results.

AG401-03-0573

Both agencies recommended immediate closure of the pit. The pit was closed by adding clay to absorb the waste POL material, and soil was mounded over the pit to promote surface water runoff. Closure was approved by the state and USEPA and was completed in 1981 (Army Environmental Hygiene Agency [AEHA], 1986).

A Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was performed in 1991 to determine whether hazardous constituents had been released to site groundwater. Four groundwater monitoring wells (14-G1, 14-G2, 14-G3, and 14-G4) were installed crossgradient and downgradient from the closed pit (Figure 1). Because benzene and six RCRA metals were detected in groundwater samples, a Phase II RFI was performed in 1995. The Phase II investigation included installing and sampling five additional groundwater monitoring wells (14-G5, 14-G6, 14-G7, 14-G8, 14-G9) in the vicinity of the closed POL pit (Figure 1) (Metcalf & Eddy, Inc., 1995).

In May 1996, a pilot-scale bioventing system was installed at SWMU 14 by Parsons ES as part of the Air Force Center for Environmental Excellence (AFCEE) Extended Bioventing Project (Figures 2 and 3). The installed bioventing system consisted of two vent wells (VW1 and VW2), three MPs (MPA, MPB, MPC), and a blower unit. An additional, background MP (MPD) was installed approximately 600 feet east of the VWs. The initial bioventing test consisted of soil and soil gas sampling and *in situ* respiration and air permeability testing. The results from the initial bioventing tests indicated that oxygen levels within the contaminated soil zones were depleted, and that air-injection bioventing is an effective method for providing oxygen to the deeper vadose zone soils. However, oxygen delivery, for the purpose of promoting aerobic biodegradation of hydrocarbon-contaminated soils, was limited within the shallow, perched, saturated zone. A detailed description of the bioventing system design and initial site activities and results are provided in the Interim Bioventing Pilot Test Results report prepared by Parsons ES (1996) for this site. In addition to the pilot-scale bioventing system installation activities (Option 3), the site also was funded for 1 year of system operation followed by soil gas sampling and respiration testing (Option 1) under the AFCEE Extended Bioventing Project.

In September 1996, Parsons ES revisited the site to determine if shallow vadose zone soils not oxygenated during bioventing system startup (in May 1996) were now receiving oxygen. Soil gas measurements from site MPs indicated that perched water was still present and interfering with oxygen delivery in the shallow soils, but that deeper vadose zone soils were still being oxygenated. During this site visit, an area *in situ* respiration test also was performed to evaluate oxygen utilization in site soils 4 months after system startup.

The 1-year soil gas sampling and *in situ* respiration testing was performed between 13 and 21 July 1997. The system was shut down 1 month prior to sampling/testing to allow soils and soil gas to come to equilibrium in order to compare initial and 1-year conditions. The blower system was started and optimized following testing to continue bioventing treatment of site soils. During the 1-year sampling/testing event, three

additional MP screened intervals (MPA-7, MPB-7, and MPC-7) and one combination groundwater/soil gas monitoring point (MPE) were installed (Figures 2 and 3). MPA-7, MPB-7 and MPC-7 were installed at 7 feet bgs at each of the three existing MP locations to investigate soil gas conditions above the perched saturated zone. MPE was installed to assess whether bioventing system air injection was increasing DO concentrations in the perched saturated zone via oxygen diffusion from the overlying and underlying unsaturated zones. MPE was installed between MPA and MPB and constructed with 1.5-inch diameter polyvinyl chloride (PVC) casing and a 5-foot screened interval extending from 8.5 to 13.5 feet bgs.

Results of initial and 1-year soil and soil gas sampling, initial and 1-year respiration testing, and the July 1997 DO measurements in perched groundwater at Site SWMU 14 are presented in this report. In addition, groundwater sampling was performed by Metcalf & Eddy, Inc. on 9 and 10 July 1997 and these results also are summarized in this report.

EXISTING SOIL DATA AND STATE OF ALABAMA CRITERIA

Soil sampling was performed during installation of the pilot-scale bioventing system in May 1996 and during the installation of MPE in July 1997. Soil samples were analyzed for total petroleum hydrocarbons (TPH) by USEPA Method SW8015 (modified for diesel-range organics) and for benzene, toluene, ethylbenzene, and xylenes (BTEX) by USEPA Method SW8020. Table 1 summarizes the 1996 and 1997 soil analytical results.

Based on the initial soil data collected prior to bioventing system installation and operation, hydrocarbon contamination levels in soils exceeded the generic Alabama Department of Environmental Management (ADEM, 1995) corrective action limit (CAL) of 100 milligrams per kilogram (mg/kg) for TPH (Table 1). Initial TPH results indicated soil contamination to be most significant between 10 and 20 feet bgs. In addition, while no ADEM CALs currently exist for BTEX; these compounds also were detected at relatively high concentrations within the 10 to 20 feet bgs soil zone (the zone roughly coinciding with the perched saturated zone). Soils greater than 20 feet bgs and above the groundwater table (44 feet bgs) met the TPH CAL of 100 mg/kg prior to bioventing system startup. BTEX compounds were not detected in these deep soils above their respective method detection limits.

At present, the ADEM (1995) TPH criterion represents the generic CAL for soil. However, ADEM supports the establishment of less stringent site-specific alternative corrective action limits (ACLs) by conducting a risk-based evaluation to determine threats to human health and the environment. The procedure for establishing the ACLs is reviewed on a site-by-site basis by ADEM. In addition, ADEM is in the process of finalizing a new risk-based corrective action (RBCA) program for evaluating petroleum-contaminated sites. The forthcoming program, which is expected to be finalized in late 1997 or 1998, will be a tiered, risk-based approach that is similar to the American Society for Testing and Materials (ASTM, 1995) RBCA decision-making

process. If site-specific ACLs are developed for SWMU 14, or the site is evaluated under the forthcoming RBCA program, the TPH CAL is likely to be replaced with risk-based concentration limits for BTEX and/or polynuclear aromatic hydrocarbon (PAH) compounds. Based on the initial soil data, BTEX compounds at the site may be of concern especially in the shallow zone between 10 and 20 feet bgs. PAH compounds, which have not been evaluated in site soils, also may be of concern within the shallow soil zone.

SOIL GAS CHEMISTRY RESULTS

Field screening and collection of soil gas samples for laboratory analysis were performed on 13 and 14 July 1997 following approximately 1 year of system operation and 1 month of system shutdown. Soil gas samples were collected from each MP interval, and field-screened to assess soil gas concentrations of oxygen, carbon dioxide, and total volatile hydrocarbons (TVH). In addition, soil gas samples for laboratory analysis were collected from the same MP screened intervals sampled during May 1996. A soil gas sample also was collected from newly installed MPE and submitted for laboratory analysis. For both the initial and 1-year soil gas sampling events, laboratory samples were sent to Air Toxics, Ltd. in Folsom, California and analyzed for TVH and BTEX using USEPA Method TO-3. Field and laboratory soil gas sampling results from May 1996 and July 1997 are presented in Table 2.

Static oxygen concentrations in soil gas have generally increased with continued air injection bioventing at the site (Table 2). The overall increases in soil gas oxygen concentrations, especially at depths greater than 20 feet bgs, indicate that aerobic hydrocarbon biodegradation rates have decreased substantially, suggesting that little substrate (fuel hydrocarbon contamination) remains in the soil at these locations. The only locations where oxygen levels had not increased over the 1-year treatment period were at the 20 foot depths at MPB (MPB-20) and MPC (MPC-20), where 1-year oxygen concentrations in soil gas were significantly lower than initial values.

Residual fuel hydrocarbons in site soils have been significantly reduced as indicated by the large decreases in TVH and BTEX concentrations measured in soil gas samples collected after 1 year of system operation. Soil gas TVH field screening results from site VWs and MPs (Table 2) indicate a 1 to 4 order of magnitude reduction. Similarly, with the exception of sample results from MPB-20, laboratory TVH concentrations were reduced 1 to 2 orders of magnitude during the first year of system operation. At MPB-20, TVH concentrations were reduced from 5,000 parts per million, volume per volume (ppmv) to 1,000 ppmv. BTEX concentrations in soil gas collected from MPA-20, MPA-40, MPC-30, and MPC-40 have been reduced 3 orders of magnitude during the first year of system operation. Lesser, but significant BTEX reductions also were measured in samples from MPB-20 and MPC-20.

Soil gas results for the newly installed, shallow MP screened intervals (MPA-7, MPB-7, MPC-7, MPE-8.5) indicate that little fuel contamination is present in the soil

above the perched saturated zone and that sufficient oxygen is available to sustain aerobic fuel biodegradation of any residual contamination present in this zone.

The lesser reductions in TVH and BTEX concentrations and low oxygen concentrations in soil gas samples from the 20-foot depths at MPB and MPC may be the result of perched, contaminated water immediately above this soil zone which is acting as a source of vapor phase fuel hydrocarbons. During the 1-year sampling event, the close proximity of the overlying perched water was evident by the near saturated conditions (as indicated by high sample extraction vacuums and difficulty collecting soil gas samples) at MPB-20 and MPC-20. Based on the 1-year soil gas sampling results, shallow (less than 10 feet bgs) and deep (greater than 20 feet bgs) site soils appear to be well oxygenated and relatively clean; however, soils in the vicinity of MPB-20 and MPC-20 remain anaerobic and still contain substantial concentrations of petroleum hydrocarbons. Continued air injection bioventing appears to be warranted for further remediation of these soils.

RESPIRATION TEST RESULTS

Four-month *in situ* respiration testing was performed at SWMU 14 from 17 to 18 September 1996. The test was performed according to protocol procedures (Hinchee *et al.*, 1992) as an area respiration test. The area test was initiated by shutting down the blower and measuring changes in oxygen, carbon dioxide, and TVH soil gas concentrations over a 17-hour period. Respiration measurements were recorded for three screened MP intervals (MPA-20, MPA-40, and MPC-30) at SWMU 14 and aerobic fuel biodegradation rates were calculated.

One-year *in situ* respiration testing was performed at SWMU 14 from 14 to 17 July 1997. The 1-year test also was performed according to protocol procedures (Hinchee *et al.*, 1992), but like the initial (May 1996) testing was performed as a point respiration test. The 1-year test followed 1 month of bioventing system shutdown. For this test, air was injected for approximately 20 hours into five MPs (MPA-7, MPA-20, MPA-40, MPB-20, and MPC-30), using 1 cubic-foot-per-minute (cfm) pumps, to oxygenate site soils. Changes in oxygen, carbon dioxide, and TVH soil gas concentrations were monitored over 47- and 71-hour periods. Observed rates of oxygen utilization were again used to estimate aerobic fuel biodegradation rates following 1 year of air injection bioventing. Initial, 4-month, and 1-year respiration and fuel biodegradation rates for site soils are shown on Table 3.

Observed oxygen utilization rates have decreased significantly as a result of 1 year of air injection bioventing at SWMU 14, however, the rates at the 20-foot depths are still significant. As can be seen from Table 3, significant reductions occurred in respiration and fuel biodegradation rates at MPA-40 and MPC-30 following the first year of system operation. One-year respiration rates measured only 2 to 3 percent of the initial values at these locations. Calculated fuel biodegradation rates have similarly decreased with extended system operation. Oxygen utilization and fuel biodegradation rates typically decrease with continued bioventing as the lighter, more readily

biodegraded hydrocarbons are preferentially destroyed over more biologically recalcitrant, higher molecular weight hydrocarbons. However, significant fuel biodegradation is still occurring at MPA-20 and MPB-20 where rates of 140 milligrams of fuel hydrocarbon per kilogram of soil per year (mg/kg/year) and 380 mg/kg/year, respectively, were measured following 1 year of bioventing treatment. These relatively high biodegradation rates correspond to the anaerobic/oxygen depleted soil gas conditions at these locations which were measured after 1 month of system shutdown. Based on these elevated respiration and fuel biodegradation rates, site soils located approximately 20 feet bgs would appear to benefit from continued bioventing system operation.

GROUNDWATER

Perched Saturated Zone

In order to determine if bioventing system operation was causing passive oxygenation of the perched saturated zone, DO concentrations in the perched groundwater were measured during 1-year testing. In July 1997, the top of the perched saturated zone was measured at depths approximately 7 to 10 feet bgs and the base of the zone at approximately 14 to 20 feet bgs. Approximately 25 feet of unsaturated soil separates the perched zone from the regional aquifer (Figure 3). DO in the perched saturated zone was measured at two locations (MPE and VW2) before the blower was restarted and again following three days of air injection into VW1 and VW2. Prior to starting the blower, the DO concentrations at MPE and VW2 were 4.4 milligrams per liter (mg/L) and 0.63 mg/L, respectively. Following three days of blower operation, 1.88 mg/L and 0.78 mg/L of DO, respectively, were measured at these same two locations. The initial DO measurements in the perched saturated zone are inconclusive as it is difficult to ascertain whether passive oxygenation of the perched saturated zone is occurring with air injection bioventing. The depleted DO concentrations observed at VW-2 indicate that microbial oxygen consumption and biodegradation of dissolved fuel hydrocarbons is occurring, but at rates limited by oxygen availability. DO increases in the perched saturated zone resulting from passive oxygenation may be more apparent with longer-term bioventing system operation prior to DO measurement.

Water Table Aquifer

Closing the waste POL pit combined with bioventing remediation of unsaturated site soils, appears to have eliminated, or greatly reduced, the continuing source of groundwater BTEX contamination in the water table aquifer. Although relatively high concentrations of TPH and BTEX likely exist in the perched, saturated zone, the approximately 25-foot thick zone of relatively clean, unsaturated soil beneath the perched saturated zone appears to be preventing or greatly reducing downward migration of contaminants.

Groundwater sampling locations are shown on Figure 1, and Table 4 summarizes groundwater analytical results for sampling efforts performed by Metcalf & Eddy in

1991, 1994, and 1997. Results of the Phase I RFI (1991) and Phase II RFI (1994) indicate that groundwater downgradient of the closed POL pit has been impacted by fuel hydrocarbons and metals. In 1991 and 1994, the highest concentrations of BTEX were measured in wells immediately downgradient of the former POL pit (14-G3, 14-G4, and 14-G6) and benzene exceeded the ADEM CAL of 5 micrograms per liter ($\mu\text{g/L}$); however, dissolved BTEX concentrations decreased between these two sampling events. Quarterly groundwater monitoring was initiated at the site in July 1997, and results from this initial quarterly event indicate a continued decrease in dissolved contaminant concentrations near the former pit, but an increase in contaminant concentrations in wells farther downgradient from the former pit (14-G7 and 14-G9). During this most recent sampling, benzene exceeded the ADEM CAL at well 14-G9, which is the farthest downgradient site well. Benzene was not detected in groundwater samples collected from wells 14-G3, 14-G4, and 14-G6 (which initially had the highest benzene concentrations in 1991). These groundwater monitoring results suggest that minimal leaching of BTEX compounds from the original source area into the water table aquifer is now occurring and that the concentrations of BTEX compounds remaining in the groundwater are being reduced by natural processes. While the downgradient extent of the dissolved contaminant plume is not evident from these sample results, the apparent source of groundwater contamination has been significantly reduced and plume stabilization and decay will follow with ongoing natural attenuation of the dissolved contaminants.

CONCLUSIONS AND RECOMMENDATIONS

Based on these findings, residual BTEX, and to a lesser degree TPH, compounds in site soils between 20 and 40 feet bgs have been greatly reduced as the result of 1 year of bioventing remediation. Although relatively high concentrations of BTEX and TPH likely remain in the perched, saturated soil zone, the 20 to 25 feet of "clean" soils underlying the perched saturated zone appear to have greatly reduced the potential for contaminant migration to the water table aquifer. Decreasing groundwater BTEX concentrations measured between 1991 and 1997 is evidence that little contamination is currently migrating from the original source area (the POL pit) to the groundwater.

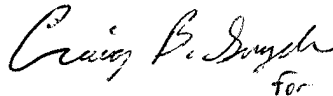
Parsons ES recommends that the US Army continue to operate the bioventing system for an additional year to eliminate the potential for contaminant leaching from the perched, saturated zone to underlying groundwater. Sustained bioventing system operation will continue to oxygenate soils between the perched, saturated zone and the water table aquifer and enhance aerobic biodegradation of any petroleum hydrocarbon contaminants which may leach from the perched zone. In addition, continued bioventing system operation will promote oxygen delivery to the perched saturated zone through diffusion, and further remediate soils in the vicinity of MPB-20 and MPC-20. At the end of the additional year of system operation, another respiration testing/soil gas sampling event should be performed. If these results are favorable, it is recommended that a risk-based closure in accordance with ADEM requirements be pursued for SWMU 14.

Based on the available historical groundwater data, dissolved hydrocarbon contaminants appear to be biodegrading, but further evaluation and documentation of the ongoing natural attenuation processes (similar to that described by Wiedemeier et al., 1995) at SWMU 14 may be warranted. Demonstration of ongoing natural attenuation of dissolved contaminants has frequently preceded successful risk-based closure of many similar sites.

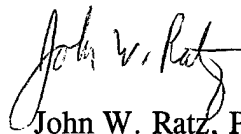
This report is the final deliverable for SWMU 14 under the AFCEE Extended Bioventing Project; however, the US Army Environmental Center (USAEC) through an Air Force Air Mobility Command contract has submitted a request for proposal to Parsons ES for continued bioventing system operation and additional remediation services at SWMU 14. If you have any questions or require additional information, please contact either John Hall at (970) 244-8829, or me at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.

A handwritten signature in cursive script, appearing to read "Craig B. Douglas", with the word "for" written in small letters below it.

John F. Hall, P.E.
Site Manager

A handwritten signature in cursive script, appearing to read "John W. Ratz".

John W. Ratz, P.E.
Project Manager

Attachments:

cc: File 727876.72210.E Letter Results Report

REFERENCES

- Alabama Department of Environmental Management. 1995. Alabama Underground Storage Tank Release Investigation and Corrective Action Guidance Manual. May.
- Army Environmental Hygiene Agency. 1986.
- American Society of Testing and Materials. 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. Designation E 1739-95. November.
- Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frendt. 1992. Test Plan and Technical Protocol for a Field Treatability Test for Bioventing. Denver, Colorado. May.
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- Metcalf & Eddy, Inc. 1997. July 1997 Quarterly Report for Natural Attenuation Monitoring at Fort Rucker, Alabama. August.
- Parsons Engineering Science, Inc. 1996. Interim Bioventing Pilot Test Results Report for the Closed Waste POL Pit, SWMU 14, Fort Rucker, Alabama. Denver, Colorado. August.
- Wiedemeier, T.H., J.T. Wilson, D.H. Kampbell, R.N. Miller, J.E. Hansen. 1995. Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater. For the Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas. By Parsons Engineering Science, Inc., Denver, Colorado. November 11.

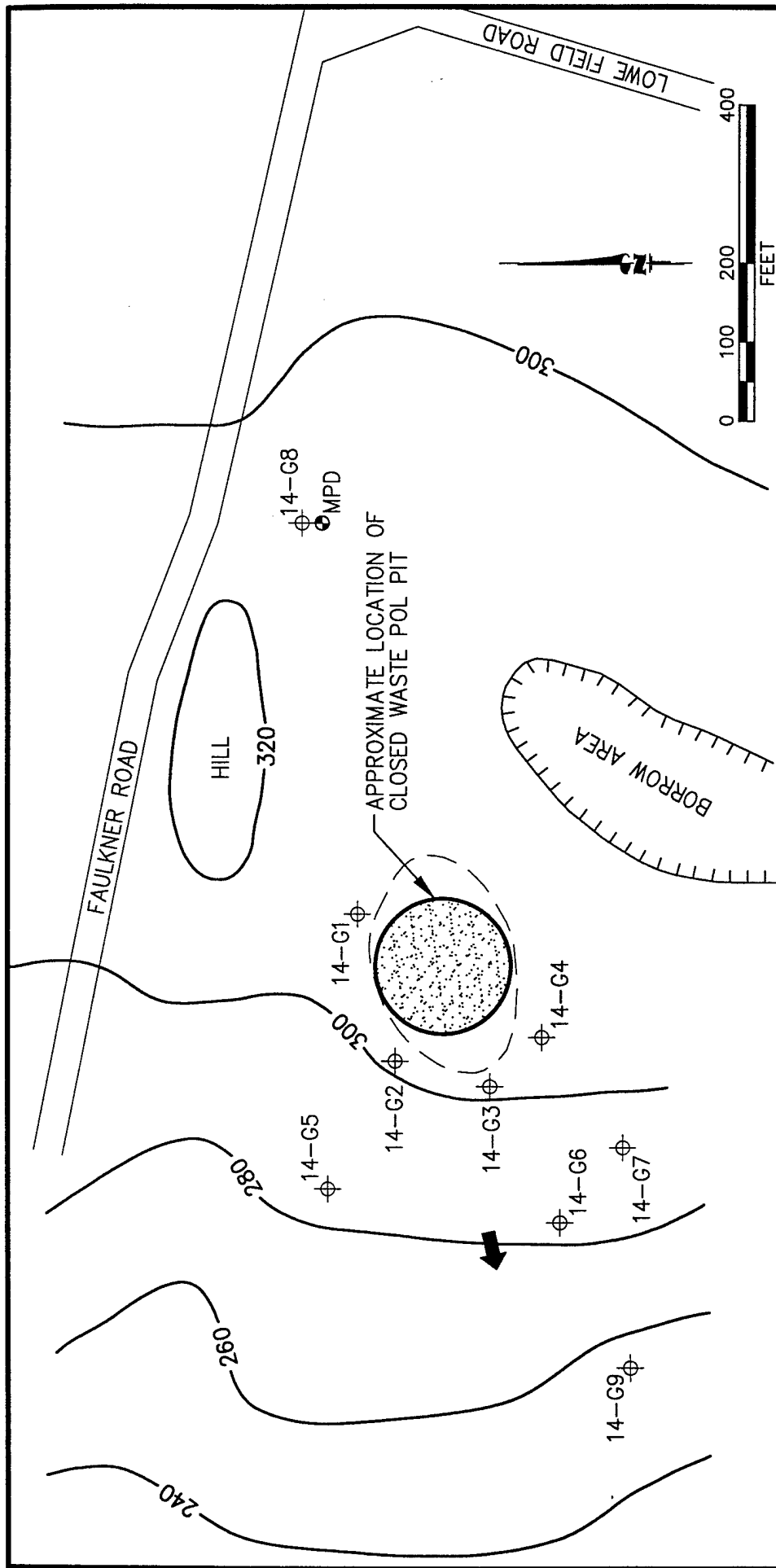


FIGURE 1

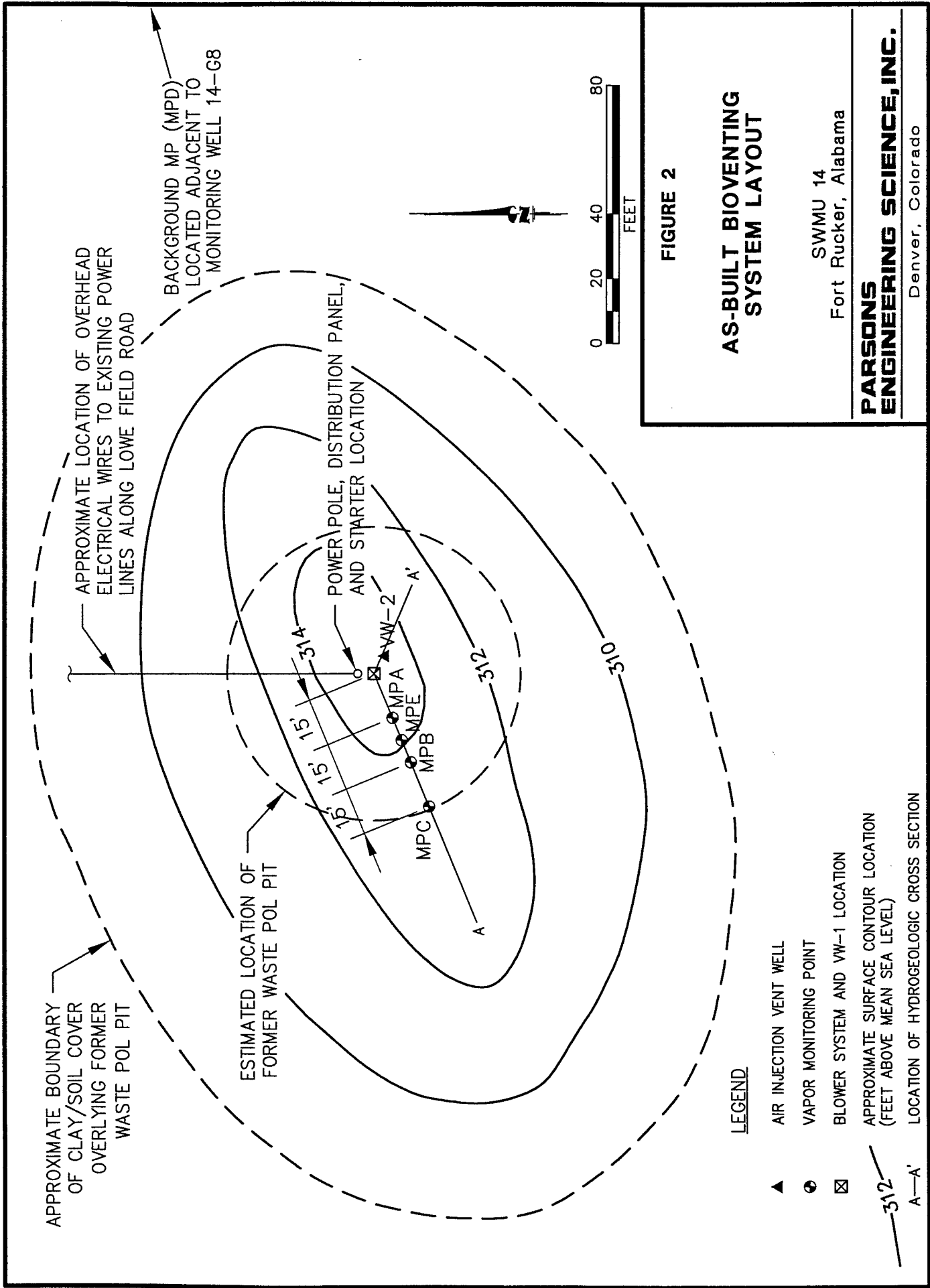
SITE LAYOUT

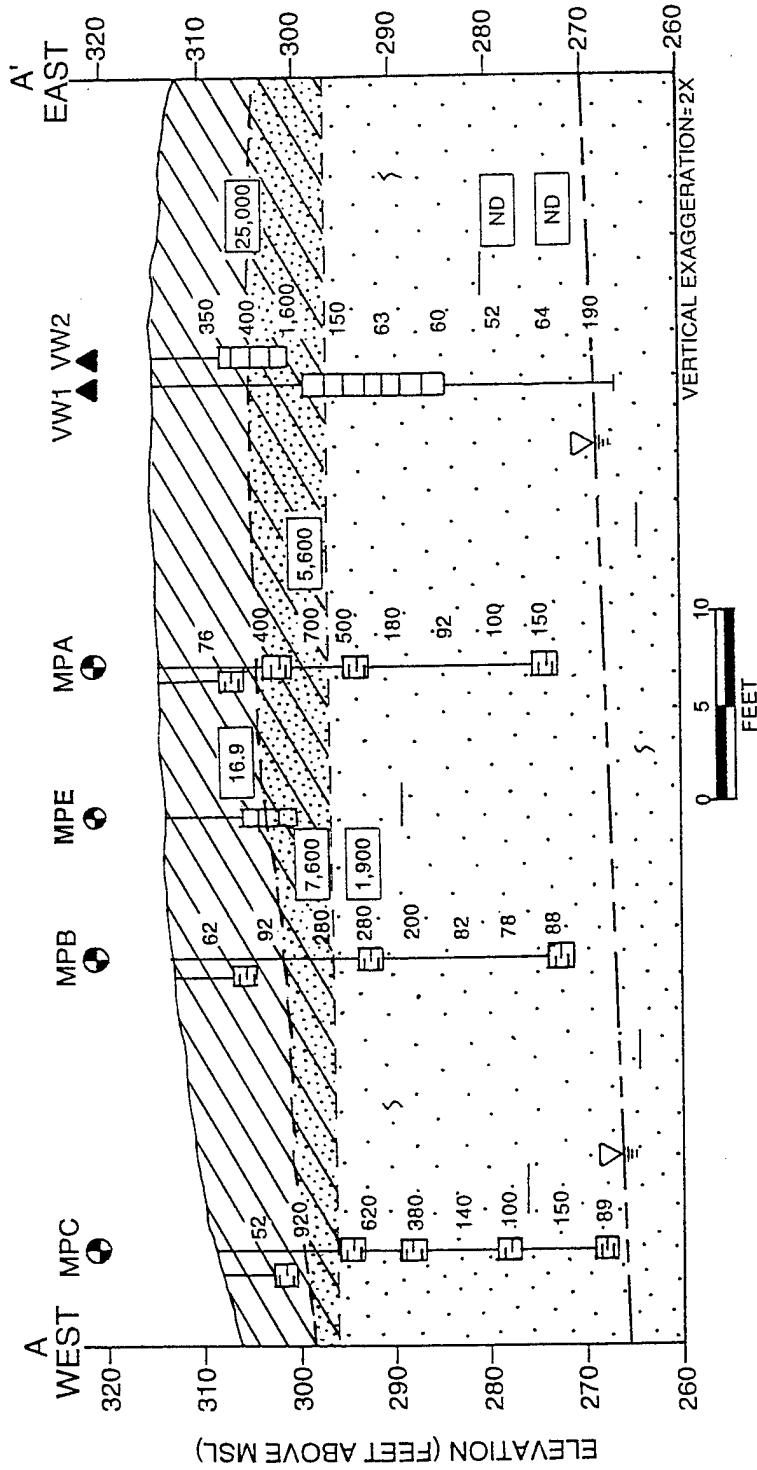
SWMU 14
Fort Rucker, Alabama

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

- () — APPROXIMATE BOUNDARY OF CLAY/ SOIL COVER OVERLYING FORMER WASTE POL PIT
- 14-G3 ⊕ GROUNDWATER MONITORING WELL (INSTALLED BY METCALF AND EDDY)
- 300 — GROUND SURFACE CONTOUR INTERVAL (FEET ABOVE MEAN SEA LEVEL)
- ⊙ BIOVENTING PILOT TEST AREA
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- ⊙ MPD BACKGROUND SOIL GAS MONITORING POINT





NOTE: This Hydrogeologic Cross-Section Depicts Subsurface Conditions as they Existed in May 1996. MPE and Shallow Screens at MPA, MPB, and MPC were Installed in July 1997.

LITHOLOGIC DESCRIPTION

LEGEND	FILL, SILTY, CLAYEY SAND	SILTY, CLAYEY SAND	SATURATED TO NEAR SATURATED SOIL
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MPA VAPOR MONITORING POINT

VW1 INJECTION VENT WELL

380 FIELD SCREENING RESULTS FOR TOTAL VOLATILE HYDROCARBONS (ppmv)

5,600 LABORATORY RESULTS FOR SOIL TOTAL PETROLEUM HYDROCARBONS (mg/kg)

--- GROUNDWATER SURFACE, DASHED WHERE INFERRED

--- APPROXIMATE LOCATION OF BASE OF FORMER PIT

☐ MONITORING POINT SCREENED INTERVAL

☐ VENT WELL SCREENED INTERVAL

FIGURE 3

HYDROGEOLOGIC CROSS SECTION A-A'

SWMU 14
Fort Rucker, Alabama

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

TABLE 1
SOIL ANALYTICAL RESULTS COMPARED TO ADEM CRITERIA
CLOSED WASTE POL PIT, SMWU 14
Fort Rucker, Alabama

	Analyte ^{a/}				
	TPH (mg/kg) ^{b/}	Benzene (µg/kg) ^{c/}	Toluene (µg/kg)	Ethylbenzene (µg/kg)	Xylenes (µg/kg)
<u>Corrective Action Limit^{d/}</u>	100	NA ^{e/}	NA	NA	NA
<u>Initial Sample Location^{f/}</u>					
VW1-10	25,000 ^{g/}	370 J ^{h/}	< 620 ^{i/}	1,500	8,500
VW1-35	< 11	< 4.4	< 4.4	< 4.4	< 4.4
VW1-40	< 11	< 4.4	< 4.4	< 4.4	< 4.4
MPA-15	5,600	190 J	< 580	540 J	2,900
MPB-15	7,600	200 J	< 800	600 J	2,200
MPB-20	1,900	1.3 J	< 5.4	1.9 J	4.4 J
MPD-15	---- ^{j/}	< 4.3	< 4.3	< 4.3	< 4.3
<u>1-Year Sample Location^{k/}</u>					
MPE-11	16.9	< 5.0	< 10.0	< 10.0	< 10.0

^{a/} TPH = total petroleum hydrocarbons analyzed by EPA Method SW8015 (modified); BTEX analyzed by EPA Method SW8020.

^{b/} mg/kg = milligrams per kilogram.

^{c/} µg/kg = micrograms per kilogram.

^{d/} ADEM corrective action limit.

^{e/} NA = not applicable. Corrective action limit has not been established.

^{f/} Sample location gives location of boring and sample depth in feet below ground surface. Initial soil sampling performed in May 1996.

^{g/} Box indicates analyte exceeds ADEM corrective action limit.

^{h/} J = indicates a laboratory estimated value; compound was detected, but below the laboratory reporting limit.

^{i/} < = compound analyzed for, but not detected. Number shown represents the laboratory method detection limit.

^{j/} ---- = Sample not analyzed for this compound.

^{k/} 1-year soil sampling performed in July 1997, following 1-month of blower shutdown.

TABLE 2
INITIAL AND 1-YEAR SOIL GAS FIELD AND LABORATORY ANALYTICAL RESULTS
CLOSED WASTE POL PIT, SMWU 14
Fort Rucker, Alabama

Sample Location	Sample Depth (ft bgs) ^{c/}	Sampling Event ^{d/}	Field Screening Data			Laboratory Analytical Data ^{a/}				
			Oxygen (percent)	Carbon Dioxide (percent)	TVH ^{b/} (ppmv) ^{e/}	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
VW-1	15-30	Initial	8.8	7.8	8,400	NA ^{f/}	NA	NA	NA	NA
		1-Year	11.8	6.8	96	NA	NA	NA	NA	NA
VW-2	7-10	Initial	16.3	4.9	2,800	NA	NA	NA	NA	NA
		1-Year	18.5	1.4	92	NA	NA	NA	NA	NA
MPA	7	Initial	---- ^{g/}	----	----	NA	NA	NA	NA	NA
		1-Year	10.0	8.0	360	NA	NA	NA	NA	NA
MPA	12	Initial	Sat. ^{h/}	Sat.	Sat.	NA	NA	NA	NA	NA
		1-Year	Sat.	Sat.	Sat.	NA	NA	NA	NA	NA
MPA	20	Initial	0.0	12.2	16,400	3,600	24	5.5	2	2.5
		1-Year	9.0	3.8	84	22	<0.002 ^{i/}	0.006	0.002	0.009
MPA	40	Initial	0.0	14.9	14,400	8,000	19	15	2.0	2.5
		1-Year	20.0	0.5	4	190	<0.002	0.016	0.004	0.042
MPB	7	Initial	----	----	----	NA	NA	NA	NA	NA
		1-Year	16.5	4.3	520	NA	NA	NA	NA	NA
MPB	20	Initial	8.0	6.6	6,800	5,000	8.1	2.6	0.37	0.55
		1-Year	0.0	6.0	480	1,000	0.68	0.85	0.26	1.0
MPB	40	Initial	0.0	15.0	13,600	NA	NA	NA	NA	NA
		1-Year	20.1	0.5	4	NA	NA	NA	NA	NA
MPC	7	Initial	----	----	----	NA	NA	NA	NA	NA
		1-Year	20.4	0.5	12	NA	NA	NA	NA	NA
MPC	14	Initial	11.0	6.0	8,800	NA	NA	NA	NA	NA
		1-Year	Sat.	Sat.	Sat.	NA	NA	NA	NA	NA
MPC	20	Initial	8.0	7.2	6,400	3,000	5.5	1.7	0.15	0.065
		1-Year	0.0	2.2	88	170	0.026	0.076	0.068	0.33
MPC	30	Initial	0.0	13.0	11,200	5,600	13	4.7	2.5	0.31
		1-Year	17.0	0.5	24	82	< 0.002	0.003	< 0.002	0.003
MPC	40	Initial	0.0	14.8	10,000	6,200	14	15M ^{j/}	4.2	5.0
		1-Year	19.5	0.5	16	240	< 0.007	0.009	0.003	0.034
MPE	8.5 ^{k/}	Initial	----	----	----	----	----	----	----	----
		1-Year	14.0	5.5	12	2	< 0.002	0.002	< 0.002	0.002

^{a/} Laboratory analysis of soil gas performed using USEPA Method TO-3. Laboratory TVH referenced to jet fuel (MW = 156).

^{b/} TVH = total volatile hydrocarbons.

^{c/} ft bgs = feet below ground surface.

^{d/} Soil gas sampling performed in May 1996 (initial), and July 1997 (1-year).

^{e/} ppmv = parts per million, volume per volume.

^{f/} NA = not analyzed.

^{g/} ---- = Sample not available. Sample point not installed until 1-year sampling event.

^{h/} Sat. = Indicates that soil was saturated with water at this location preventing collection of a soil gas sample.

^{i/} < = compound analyzed for, but not detected. Number shown represents the laboratory method detection limit.

^{j/} Laboratory reported value may be biased due to apparent matrix interferences.

^{k/} The effective screened interval of MPE was less than 0.5 foot during 1-year sampling due to the presence of perched water at 8.9 feet bgs.

TABLE 3
INITIAL, 4-MONTH, AND 1-YEAR RESPIRATION AND BIODEGRADATION RATES
CLOSED WASTE POL PIT, SMWU 14
Fort Rucker, Alabama

Location-Depth (feet bgs) ^{b/}	Initial (May 1996)		4-Month (September 1996) ^{d/}		1-Year (July 1997)	
	Respiration Rate (% O ₂ /hr) ^{e/}	Biodegradation Rate (mg/kg/year) ^{d/}	Soil Temperature (°C)	Respiration Rate (% O ₂ /hr)	Biodegradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA-7	NM ^{e/}	NC ^{d/}	NM	NM	NC	NM
MPA-20	0.26	870	16.0	0.062	210	NM
MPA-40	0.12	400	18.3	0.0018	6	NM
MPB-20	NC	NC	NM	NM	NC	NM
MPC-30	0.19	640	NM	0.0057	19	NM
				0.092	300	NM
				0.042	140	22.5
				0.0039	13	18.1
				0.11	380	NM
				0.0043	14	NM

^{a/} The 4-month test was an area *in situ* respiration test. Initial and 1-year tests were point *in situ* respiration tests.

^{b/} feet bgs = feet below ground surface.

^{c/} % O₂/hr = Percent oxygen per hour.

^{d/} mg/kg/year = Milligrams of hydrocarbons per kilogram of soil per year.

^{e/} NM = not measured.

^{f/} NC = not calculated.

TABLE 4
GROUNDWATER ANALYTICAL RESULTS COMPARED TO ADEM CRITERIA
CLOSED WASTE POL PIT, SMWU 14
Fort Rucker, Alabama

		Benzene (µg/L) ^{a/}	Toluene (µg/L)	Ethyl- benzene (µg/L)	Xylenes (µg/L)
	Corrective Action Limit ^{b/}	5	1,000	700	10,000
Sample Location	Sample Date				
14-G1	7/12/91 ^{c/}	< 5.0 ^{d/}	< 5.0	< 5.0	< 5.0
	1/4/94 ^{c/}	< 0.5	< 5.0	< 5.0	< 0.84
	7/10/97 ^{e/}	< 1.0	< 1.0	< 1.0	< 1.0
14-G2	7/12/91	< 5.0	< 5.0	< 5.0	< 5.0
	1/4/94	< 0.5	< 0.5	< 0.5	< 0.84
	7/10/97	< 1.0	< 1.0	< 1.0	< 1.0
14-G3	7/13/91	110 ^{f/ g/}	< 5.0	< 5.0	140
	1/4/94	27	< 0.5	< 0.5	20
	7/9/97	< 1.0	< 1.0	< 1.0	< 1.0
14-G4	7/13/91	400	600	200	2000
	1/4/94	70	200	200	1000
	7/9/97	< 5.0	100	99	180
14-G5	1/4/94	< 0.5	< 0.5	< 0.5	< 0.84
14-G6	1/4/94	64	< 0.50	< 0.50	32
	7/9/97	< 1.0	< 1.0	< 1.0	< 1.0
14-G7	1/4/94	< 0.5	< 0.5	< 0.5	< 0.84
	7/9/97	2.3	< 1.0	12	42
14-G8	1/5/94	< 0.5	< 0.5	< 0.5	< 0.84
14-G9	1/4/94	16.5	< 0.5	< 0.5	< 0.84
	7/10/97	74	< 2.0	< 2.0	10.7

^{a/} µg/L = micrograms per liter.

^{b/} ADEM (1995) generic corrective action limit.

^{c/} 1991 and 1994 groundwater sample results from Metcalf & Eddy (1995).

^{d/} < = analyte concentration is less than the laboratory reporting limit shown.

^{e/} 1997 groundwater sample results from Metcalf & Eddy (1997).

^{f/} Shading indicates analyte detected above laboratory reporting limit.

^{g/} Box indicates analyte exceeds ADEM corrective action limit.

PARSONS ENGINEERING SCIENCE, INC.

1700 Broadway, Suite 900 • Denver, Colorado 80290 • (303) 831-8100 • Fax: (303) 831-8208

9 October 1997

Major Ed Marchand
AFCEE/ERT
3207 North Road, Bldg 532
Brooks AFB, Texas 78235-5363

Subject: Revisions to Table 2 of the Extended Bioventing Testing Results for the
Closed Waste POL Pit, SWMU 14, Fort Rucker, AL

Dear Major Marchand:

Per your request, Table 2 of the 16 September 1997 letter report presenting the results of the bioventing system monitoring performed by Parsons Engineering Science, Inc. (Parsons ES) in July 1997 at the Closed Waste Petroleum, Oils, and Lubricants (POL) Pit, Solid Waste Management Unit (SWMU) 14, at Fort Rucker, Alabama, has been modified to include background data at monitoring point (MP) D. MPD was sampled on 17 May 1996 as part of the initial bioventing pilot test. Three copies of the revised Table 2, which supersedes the copy included in the letter report, has been attached for your use.

If you have any questions or if I may be of further assistance, please contact me at (303) 764-1909.

Sincerely,
PARSONS ENGINEERING SCIENCE, INC.



John Ratz, P.E.
Project Manager

cc: Mr. Gene L. Fabian, USAEC
Mr. Jim Swift, Fort Rucker
File 726876.72210.45.01

Attachment

TABLE 2
INITIAL AND 1-YEAR SOIL GAS FIELD AND LABORATORY ANALYTICAL RESULTS
CLOSED WASTE POL PIT, SMWU 14
Fort Rucker, Alabama

Sample Location	Sample Depth (ft bgs) ^{c/}	Sampling Event ^{d/}	Field Screening Data			Laboratory Analytical Data ^{e/}				
			Oxygen (percent)	Carbon Dioxide (percent)	TVH ^{b/} (ppmv) ^{e/}	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
VW-1	15-30	Initial	8.8	7.8	8,400	NA ^{f/}	NA	NA	NA	NA
		1-Year	11.8	6.8	96	NA	NA	NA	NA	NA
VW-2	7-10	Initial	16.3	4.9	2,800	NA	NA	NA	NA	NA
		1-Year	18.5	1.4	92	NA	NA	NA	NA	NA
MPA	7	Initial	--- ^{g/}	---	---	NA	NA	NA	NA	NA
		1-Year	10.0	8.0	360	NA	NA	NA	NA	NA
MPA	12	Initial	Sat. ^{h/}	Sat.	Sat.	NA	NA	NA	NA	NA
		1-Year	Sat.	Sat.	Sat.	NA	NA	NA	NA	NA
MPA	20	Initial	0.0	12.2	16,400	3,600	24	5.5	2	2.5
		1-Year	9.0	3.8	84	22	<0.002 ^{i/}	0.006	0.002	0.009
MPA	40	Initial	0.0	14.9	14,400	8,000	19	15	2.0	2.5
		1-Year	20.0	0.5	4	190	<0.002	0.016	0.004	0.042
MPB	7	Initial	---	---	---	NA	NA	NA	NA	NA
		1-Year	16.5	4.3	520	NA	NA	NA	NA	NA
MPB	20	Initial	8.0	6.6	6,800	5,000	8.1	2.6	0.37	0.55
		1-Year	0.0	6.0	480	1,000	0.68	0.85	0.26	1.0
MPB	40	Initial	0.0	15.0	13,600	NA	NA	NA	NA	NA
		1-Year	20.1	0.5	4	NA	NA	NA	NA	NA
MPC	7	Initial	---	---	---	NA	NA	NA	NA	NA
		1-Year	20.4	0.5	12	NA	NA	NA	NA	NA
MPC	14	Initial	11.0	6.0	8,800	NA	NA	NA	NA	NA
		1-Year	Sat.	Sat.	Sat.	NA	NA	NA	NA	NA
MPC	20	Initial	8.0	7.2	6,400	3,000	5.5	1.7	0.15	0.065
		1-Year	0.0	2.2	88	170	0.026	0.076	0.068	0.33
MPC	30	Initial	0.0	13.0	11,200	5,600	13	4.7	2.5	0.31
		1-Year	17.0	0.5	24	82	<0.002	0.003	<0.002	0.003
MPC	40	Initial	0.0	14.8	10,000	6,200	14	15M ^{j/}	4.2	5.0
		1-Year	19.5	0.5	16	240	<0.007	0.009	0.003	0.034
MPD ^{k/}	15	Initial	19.5	2.1	96	NA	NA	NA	NA	NA
	25	Initial	19.5	2.1	96	NA	NA	NA	NA	NA
	35	Initial	19.5	2.1	90	NA	NA	NA	NA	NA
MPE	8.5 ^{l/}	Initial	---	---	---	---	---	---	---	---
		1-Year	14.0	5.5	12	2	<0.002	0.002	<0.002	0.002

^{a/} Laboratory analysis of soil gas performed using USEPA Method TO-3. Laboratory TVH referenced to jet fuel (MW=156).

^{b/} TVH = total volatile hydrocarbons.

^{c/} ft bgs = feet below ground surface.

^{d/} Soil gas sampling performed in May 1996 (initial), and July 1997 (1-year).

^{e/} ppmv = parts per million, volume per volume.

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^{g/} --- = Sample not available. Sample point not installed until 1-year sampling event.

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^{i/} < = compound analyzed for, but not detected. Number shown represents the laboratory method detection limit.

^{j/} Laboratory reported value may be biased due to apparent matrix interferences.

^{k/} Background soil gas monitoring point sampled during the initial pilot test on 17 May 1996.

^{l/} The effective screened interval of MPE was less than 0.5 foot during 1-year sampling due to the presence of perched water at 8.9 feet bgs.

TABLE 2
INITIAL AND 1-YEAR SOIL GAS FIELD AND LABORATORY ANALYTICAL RESULTS
CLOSED WASTE POL PIT, SMWU 14
Fort Rucker, Alabama

Sample Location	Sample Depth (ft bgs) ^{c/}	Sampling Event ^{d/}	Field Screening Data			Laboratory Analytical Data ^{v/}				
			Oxygen (percent)	Carbon Dioxide (percent)	TVH ^{b/} (ppmv) ^{e/}	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
VW-1	15-30	Initial	8.8	7.8	8,400	NA ^{g/}	NA	NA	NA	NA
		1-Year	11.8	6.8	96	NA	NA	NA	NA	NA
VW-2	7-10	Initial	16.3	4.9	2,800	NA	NA	NA	NA	NA
		1-Year	18.5	1.4	92	NA	NA	NA	NA	NA
MPA	7	Initial	— ^{h/}	—	—	NA	NA	NA	NA	NA
		1-Year	10.0	8.0	360	NA	NA	NA	NA	NA
MPA	12	Initial	Sat. ^{h/}	Sat.	Sat.	NA	NA	NA	NA	NA
		1-Year	Sat.	Sat.	Sat.	NA	NA	NA	NA	NA
MPA	20	Initial	0.0	12.2	16,400	3,600	24	5.5	2	2.5
		1-Year	9.0	3.8	84	22	<0.002 ^{v/}	0.006	0.002	0.009
MPA	40	Initial	0.0	14.9	14,400	8,000	19	15	2.0	2.5
		1-Year	20.0	0.5	4	190	<0.002	0.016	0.004	0.042
MPB	7	Initial	—	—	—	NA	NA	NA	NA	NA
		1-Year	16.5	4.3	520	NA	NA	NA	NA	NA
MPB	20	Initial	8.0	6.6	6,800	5,000	8.1	2.6	0.37	0.55
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MPB	40	Initial	0.0	15.0	13,600	NA	NA	NA	NA	NA
		1-Year	20.1	0.5	4	NA	NA	NA	NA	NA
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		1-Year	Sat.	Sat.	Sat.	NA	NA	NA	NA	NA
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MPC	40	Initial	0.0	14.8	10,000	6,200	14	15M ^{j/}	4.2	5.0
		1-Year	19.5	0.5	16	240	<0.007	0.009	0.003	0.034
MPD ^{k/}	15	Initial	19.5	2.1	96	NA	NA	NA	NA	NA
	25	Initial	19.5	2.1	96	NA	NA	NA	NA	NA
	35	Initial	19.5	2.1	90	NA	NA	NA	NA	NA
MPE	8.5 ^{v/}	Initial	—	—	—	—	—	—	—	—
		1-Year	14.0	5.5	12	2	<0.002	0.002	<0.002	0.002

^{v/} Laboratory analysis of soil gas performed using USEPA Method TO-3. Laboratory TVH referenced to jet fuel (MW=156).

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MPA	20	Initial	0.0	12.2	16,400	3,600	24	5.5	2	2.5
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